SCYON

The Star Clusters Young & Old Newsletter

edited by Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

SCYON can be found at URL:
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SCYON Issue No. 41 — *16 December 2008*

EDITORIAL

This is the 41st issue of the SCYON newsletter. We have 13 abstracts from refereed publications and two announcements for job offers from Rochester Institute of Technology and Northwestern University.

We wish everybody a merry holiday season and a happy new year 2009 and thank all who sent us their contributions.

Holger Baumgardt, Ernst Paunzen and Pavel Kroupa

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CONTENTS

SCYON POLICY

The SCYON Newsletter publishes abstracts from any area in astronomy which are relevant to research on star clusters. We welcome all contributions. Topics to be covered include

1. Abstracts from refereed articles
2. Abstracts from conference proceedings
3. PhD summaries
4. General announcements : Conferences, new databases, and the likes.

Concerning possible infringements to copyright laws, we understand that the authors themselves are taking responsibility for the material they send us. We make no claim whatsoever to owning the material that is posted at our url or circulated by email. The newsletter SCYON is a free service. It does not substitute for our personal opinions, nor does it reflect in any way the views of our respective institutes of affiliations.

SCYON will be published initially once every two months. If the number of contributions justifies monthly installments, we will move toward more frequent issues in order to keep the newsletter relatively short, manageable for us, and up-to-date.

Conference and journal abstracts can be submitted at any time either by web download, or failing this, we also accept abstracts typeset using the latest latex abstract template (available from the SCYON webpage). We much prefer contributors to use the direct download form, since it is mostly automated. Abstracts will normally appear on the website as soon as they are submitted to us. Other contributions, such as PhD summaries, should be sent to us using the LaTeX template. *Please do not submit postscript files, nor encoded abstracts as e-mail attachments.*

All abstracts/contributions will be processed, but we reserve the right to not post abstracts submitted in the wrong format or which do not compile. If you experience any sort of problems accessing the web site, or with the LaTeX template, please write to us at scyon@astro.u-strasbg.fr.

A "Call for abstracts" is sent out approximately one week before the next issue of the newsletter is finalised. This call contains the deadline for abstract submissions for that coming issue and the LaTeX abstract template.
Depending on circumstances, the editors might actively solicit contributions, usually those spotted on a preprint server, but they do not publish abstracts without the author's consent.

We implicitly encourage further dissemination of the letter to institutes and astronomers who may benefit from it.

The editors

SCYON Mirrors

The official Scyon mirror site in Australia is hosted at the Centre for Astrophysics & Supercomputing of the University of Swinburne by Duncan Forbes and his team :

HTTP://ASTRONOMY.SWIN.EDU.AU/SCYON/)

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1. Star Forming Regions

The influence of multiple stars on the high-mass stellar initial mass function and age-dating of young massive star clusters

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The study of young stellar populations has revealed that most stars are in binary or higher order multiple systems. In this study the influence on the stellar initial mass function (IMF) of large quantities of unresolved multiple massive stars is investigated by taking into account stellar evolution an photometrically determined system masses. The models where initial masses are derived from the luminosity and colour of unresolved multiple systems show that even under extreme circumstances (100% binaries or higher order multiples) the difference between the power-law index of the mass function of all stars and the observed mass function is small (≤ 0.1). Thus, if the observed IMF has the Salpeter index $\alpha = 2.35$ then the true stellar IMF has an index not flatter than $\alpha = 2.25$. Additionally, unresolved multiple systems may hide between 15 and 60% of the underlying true mass of a star cluster. While already a known result, it is important to point out that the presence of a large number of unresolved binaries amongst pre-main-sequence (PMS) stars induces a significant spread in the measured ages of these stars even if there is none. Also, lower-mass stars in a single-age binary-rich cluster appear older than the massive stars by about 0.6 Myr.

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2. Galactic Open Clusters

Shape parameters of Galactic open clusters[1]

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Abstract

There are only a few tens of open clusters for which ellipticities have been determined in the past. In this paper we derive observed and modelled shape parameters (apparent ellipticity and orientation of the ellipse) of 650 Galactic open clusters identified in the ASCC catalogue. We provide the observed shape parameters of Galactic open clusters, computed with the help of a multi-component analysis. For the vast majority of clusters these parameters are determined for the first time. High resolution ("star by star") N-body simulations are carried out with the specially developed ϕGRAPE code providing models of clusters of different initial masses, Galactocentric distances and rotation velocities. The comparison of models and observations of about 150 clusters reveals ellipticities of observed clusters which are too low (0.2 vs. 0.3), and offers the basis to find the main reason for this discrepancy. The models predict that after ≈ 50 Myr clusters reach an oblate shape with an axes ratio of $1.65 : 1.35 : 1$, and with the major axis tilted by an angle of $q_{XY} \approx 30^\circ$ with respect to the Galactocentric radius due to differential rotation of the Galaxy. Unbiased estimates of cluster shape parameters requires reliable membership determination in large cluster areas up to 2-3 tidal radii where the density of cluster stars is considerably lower than the background. Although dynamically bound stars outside the tidal radius contribute insignificantly to the cluster mass, their distribution is essential for a correct determination of cluster shape parameters. In contrast, a restricted mass range of cluster stars does not play such a dramatic role, though deep surveys allow to identify more cluster members and, therefore, to increase the accuracy of the observed shape parameters.

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[1]The determined shape parameters for 650 clusters are listed in a table that is available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/

The low-mass Initial Mass Function in the young cluster NGC 6611

J.M. Oliveira, R.D. Jeffries, J.Th. van Loon
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NGC 6611 is the massive young cluster (2-3 Myr) that ionises the Eagle Nebula. We present very deep photometric observations of the central region of NGC 6611 obtained with the Hubble Space Telescope and the following filters: ACS/WFC F775W and F850LP and NIC2 F110W and F160W, loosely equivalent to ground-based IZJH filters. This survey reaches down to $I \sim 26$ mag. We construct the Initial Mass Function (IMF) from ~ 1.5 Msun well into the brown dwarf regime (down to ~ 0.02 Msun). We have detected 30-35 brown dwarf candidates in this sample. The low-mass IMF is combined with a higher-mass IMF constructed from the groundbased catalogue from Oliveira et al. (2005). We compare the final IMF with those of well studied star forming regions: we find that the IMF of NGC 6611 more closely resembles that of the low-mass star forming region in Taurus than that of the more massive Orion Nebula Cluster (ONC). We conclude that there seems to be no severe environmental effect in the IMF due to the proximity of the massive stars in NGC 6611.

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3. Galactic Globular Clusters

Giants in the globular cluster omega Centauri: dust production, mass loss and distance

Iain McDonald (1), Jacco Th. van Loon (1), Leen Decin (2), Martha L. Boyer (3), Andrea K. Dupree (4), Aneurin Evans (1), Robert D. Gehrz (3), Charles E. Woodward (3)

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We present spectral energy distribution modelling of 6875 stars in omega Centauri, obtaining stellar luminosities and temperatures by fitting literature photometry to state-of-the-art MARCS stellar models. By comparison to four different sets of isochrones, we provide a new distance estimate to the cluster of 4850 $\pm$ 200 (random) $\pm$ 120 (systematic error) pc, a reddening of E(B-V) = 0.08 $\pm$ 0.02 $\pm$ 0.02 mag and a differential reddening of Delta[E(B-V)] $<$ 0.02 mag for an age of 12 Gyr. Several new post-early-AGB candidates are also found. Infra-red excesses of stars were used to measure total mass-loss rates for individual stars down to $\sim 7 \cdot 10^{-8}$ Msun/yr. We find a total dust mass-loss rate from the cluster of 1.3 (+0.8/-0.5) $\cdot 10^{-9}$ Msun/yr, with the total gas mass-loss rate being $>$ 1.2 (+0.6/-0.5) $\cdot 10^{-6}$ Msun/yr. Half of the cluster's dust production and 30% of its gas production comes from the two most extreme stars - V6 and V42 - for which we present new Gemini/T-ReCS mid-infrared spectroscopy, possibly showing that V42 has carbon-rich dust. The cluster's dust temperatures are found to be typically $>\sim$ 550 K. Mass loss apparently does not vary significantly with metallicity within the cluster, but shows some correlation with barium enhancement, which appears to occur in cooler stars, and especially on the anomalous RGB. Limits to outflow velocities, dust-to-gas ratios for the dusty objects and the possibility of short-timescale mass-loss variability are also discussed in the context of mass loss from low-metallicity stars. The ubiquity of dust around stars near the RGB-tip suggests significant dusty mass loss on the RGB; we estimate that typically 0.20–0.25 Msun of mass loss occurs on the RGB. From observational limits on intra-cluster material, we suggest the dust is being cleared on a timescale of $<\sim 10^5$ years.

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The evolution of two stellar populations in globular clusters I. The dynamical mixing timescale

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AIfA, University of Bonn

We investigate the long-term dynamical evolution of two distinct stellar populations of low-mass stars in globular clusters in order to study whether the energy equipartition process can explain the high number of stars harbouring abundance anomalies seen in globular clusters. We analyse N-body models by artificially dividing the low-mass stars ($m < 0.9$ Msun) into two populations: a small number of stars (second generation) consistent with an invariant IMF and with low specific energies initially concentrated towards the cluster-centre mimic stars with abundance anomalies. These stars form from the slow winds of fast-rotating massive stars. The main part of low-mass (first generation) stars has the pristine composition of the cluster. We study in detail how the two populations evolve under the influence of two-body elaxation and the tidal forces due to the host galaxy.Stars with low specific energy initially concentrated toward the cluster centre need about two relaxation times to achieve a complete homogenisation throughout the cluster. For realistic globular clusters, the number ratio between the two populations increases only by a factor 2.5 due to the preferential evaporation of the population of outlying first generation stars. We also find that the loss of information on the stellar orbital angular momentum occurs on the same timescale as spatial homogenisation.

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4. Extragalactic Clusters

The Spatial Evolution of Stellar Structures in the LMC

Nate Bastian ([1]), Mark Gieles ([2]), Barbara Ercolano ([1]), Robert Gutermuth ([3])
1) IoA Cambridge, 2) ESO Santiago, 3) CfA

We present an analysis of the spatial distribution of various stellar populations within the Large Magellanic Cloud. We combine mid-infrared selected young stellar objects, optically selected samples with mean ages between 9 and 1000 Myr, and existing stellar cluster catalogues to investigate how stellar structures form and evolve within the LMC. For the analysis we use Fractured Minimum Spanning Trees, the statistical Q parameter, and the two-point correlation function. Restricting our analysis to young massive (OB) stars we confirm our results obtained for M33, namely that the luminosity function of the groups is well described by a power-law with index -2, and that there is no characteristic length-scale of star-forming regions. We find that stars in the LMC are born with a large amount of substructure, consistent with a 2D fractal distribution with dimension 1.8 and evolve towards a uniform distribution on a timescale of 175 Myr. This is comparable to the crossing time of the galaxy and we suggest that stellar structure, regardless of spatial scale, will be eliminated in a crossing time. This may explain the smooth distribution of stars in massive/dense young clusters in the Galaxy, while other, less massive, clusters still display large amounts of structure at similar ages. By comparing the stellar and star cluster distributions and evolving timescales, we show that infant mortality of clusters (or 'popping clusters') have a negligible influence on galactic structure. Finally, we quantify the influence of the elongation, differential extinction, and contamination of a population on the measured Q value.

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Globular Cluster Systems in Nearby Dwarf Galaxies: I. HST/ACS Observations and Dynamical Properties of Globular Clusters at Low Environmental Density

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Abstract: We investigate the old globular cluster (GC) population of 68 faint (Mv¿-16 mag) dwarf galaxies located in the halo regions of nearby (< 12 Mpc) loose galaxy groups and in the field environment based on archival HST/ACS images in F606W and F814W filters. The combined color distribution of 175 GC candidates peaks at (V-I)=0.96 +/- 0.07 mag and the GC luminosity function turnover for the entire sample is found at Mv,to = -7.6 +/- 0.11 mag, similar to the old metal-poor LMC GC population. Our data reveal a tentative trend of Mv,to becoming fainter from late-type to early-type galaxies. The luminosity and color distributions of GCs in dIrrs shows a lack of faint blue GCs. Our analysis reveals that this might reflect a relatively younger GC system than typically found in luminous early-type galaxies. If verified by spectroscopy this would suggest a later formation epoch of the first metal-poor star clusters in dwarf galaxies. We find several bright (massive) GCs which reside in the nuclear regions of their host galaxies. These nuclear clusters have similar luminosities and structural parameters as the peculiar Galactic clusters suspected of being the remnant nuclei of accreted dwarf galaxies, such as M54 and wCen. Except for these nuclear clusters, the distribution of GCs in dIrrs in the half-light radius vs. cluster mass plane is very similar to that of Galactic young halo clusters, which suggests comparable formation and dynamical evolution histories. A comparison with theoretical models of cluster disruption indicates that GCs in low-mass galaxies evolve dynamically as self-gravitating systems in a benign tidal environment.

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Also available from the URL http://arxiv.org/abs/0810.3660

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The mass function of young star clusters in spiral galaxies

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The initial cluster mass function (ICMF) in spiral galaxy discs is constrained and compared with data for old globular clusters and young clusters in starbursts. It is found that the observed ages and luminosities of the brightest clusters in spiral discs can be reproduced if the ICMF is a Schechter function with a cut-off mass (Mc) of a few times 10^5 Msun and disruption of optically visible clusters is dominated by relatively slow secular evolution. A direct Schechter function fit to the combined cluster MF for all spirals in the sample studied here yields $M_c = (2.1 \pm 0.4) \cdot 10^5$ Msun. The MFs in cluster-poor and cluster-rich spirals are statistically indistinguishable. An $M_c = 2.1 \cdot 10^5$ Msun Schechter function also fits the MF of young clusters in the Large Magellanic Cloud. If the same ICMF applies in the Milky Way, a bound cluster with $M > 10^5$ Msun will form about once every 10 Myr, while an $M > 10^6$ Msun cluster will form only once every 50 Gyr. Luminosity functions (LFs) of model cluster populations drawn from an $M_c = 2.1 \cdot 10^5$ Msun Schechter ICMF generally agree with LFs observed in spiral galaxies. It is thus concluded that the ICMF in present-day spiral discs can be modelled as a Schechter function with $M_c = 200{,}000$ Msun. However, the presence of significant numbers of $M > 10^6$ Msun (and even $M > 10^7$ Msun) clusters in some starburst galaxies makes it unlikely that the Mc value derived for spirals is universal. In high-pressure environments, such as those created by complex gas kinematics and feedback in mergers, M_c can shift to higher masses than in quiescent discs.

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The spatial distribution of star and cluster formation in M51

R. A. Scheepmaker, H. J. G. L. M. Lamers, P. Anders, S. S. Larsen
Utrecht University

Aims. We study the connection between spatially resolved star formation and young star clusters across the disc of M51. Methods. We combine star cluster data based on B, V, and I-band Hubble Space Telescope ACS imaging, together with new WFPC2 U-band photometry to derive ages, masses, and extinctions of 1580 resolved star clusters using SSP models. This data is combined with data on the spatially resolved star formation rates and gas surface densities, as well as Halpha and 20cm radio-continuum (RC) emission, which allows us to study the spatial correlations between star formation and star clusters. Two-point autocorrelation functions are used to study the clustering of star clusters as a function of spatial scale and age. Results. We find that the clustering of star clusters among themselves decreases both with spatial scale and age, consistent with hierarchical star formation. The slope of the autocorrelation functions are consistent with projected fractal dimensions in the range of 1.2-1.6, which is similar to other galaxies, therefore suggesting that the fractal dimension of hierarchical star formation is universal. Both star and cluster formation peak at a galactocentric radius of 2.5 and 5 kpc, which we tentatively attribute to the presence of the 4:1 resonance and the co-rotation radius. The positions of the youngest (< 10 Myr) star clusters show the strongest correlation with the spiral arms, Halpha, and the RC emission, and these correlations decrease with age. The azimuthal distribution of clusters in terms of kinematic age away from the spiral arms indicates that the majority of the clusters formed 5-20 Myr before their parental gas cloud reached the centre of the spiral arm.

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5. Dynamical evolution - Simulations

Quantitative analysis of clumps in the tidal tails of star clusters

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Tidal tails of star clusters are not homogeneous but show well defined clumps in observations as well as in numerical simulations. Recently an epicyclic theory for the formation of these clumps was presented. A quantitative analysis was still missing. We present a quantitative derivation of the angular momentum and energy distribution of escaping stars from a star cluster in the tidal field of the Milky Way and derive the connection to the position and width of the clumps. For the numerical realization we use star-by-star N-body simulations. We find a very good agreement of theory and models. We show that the radial offset of the tidal arms scales with the tidal radius, which is a function of cluster mass and the rotation curve at the cluster orbit. The mean radial offset is 2.77 times the tidal radius in the outer disc. Near the Galactic centre the circumstances are more complicated, but to lowest order the theory still applies. We have also measured the Jacobi energy distribution of bound stars and showed that there is a large fraction of stars (about 35%) above the critical Jacobi energy at all times, which can potentially leave the cluster. This is a hint that the mass loss is dominated by a self-regulating process of increasing Jacobi energy due to the weakening of the potential well of the star cluster, which is induced by the mass loss itself.

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6. Miscellaneous

A New Diagnostic Method for Assessment of Stellar Stratification in Star Clusters

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We propose a new method for the characterization of stellar stratification in stellar systems. The method uses the mean-square radius (also called the Spitzer radius) of the system as a diagnostic tool. An estimate of the observable counterpart of this radius for stars of different magnitude ranges is used as the effective radius of each stellar species in a star cluster. We explore the dependence of these radii on magnitude as a possible indication of stellar stratification. This method is the first of its kind to use a dynamically stable radius, and though seemingly trivial it has never been applied before. We test the proposed method using model star clusters, which are constructed to be segregated on the basis of a Monte Carlo technique, and on Hubble Space Telescope observations of mass-segregated star clusters in order to explore the limitations of the method in relation to actual data. We conclude that the method performs efficiently in the detection of stellar stratification and its results do not depend on the data, provided that incompleteness has been accurately measured and the contamination by the field population has been thoroughly removed. Our diagnosis method is also independent of any model or theoretical prediction, in contrast to the 'classical' methods used so far for the detection of mass segregation.

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Exploring the consequences of pairing algorithms for binary stars

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Knowledge of the binary population in stellar groupings provides important information about the outcome of the star forming process in different environments (see, e.g., Blaauw 1991, and references therein). Binarity is also a key ingredient in stellar population studies, and is a prerequisite to calibrate the binary evolution channels. In this paper we present an overview of several commonly used methods to pair individual stars into binary systems, which we refer to as pairing functions. These pairing functions are frequently used by observers and computational astronomers, either for their mathematical convenience, or because they roughly describe the expected outcome of the star forming process. We discuss the consequences of each pairing function for the interpretation of observations and numerical simulations. The binary fraction and mass ratio distribution generally depend strongly on the selection of the range in primary spectral type in a sample. The mass ratio distribution and binary fraction derived from a binarity survey among a mass-limited sample of targets is thus not representative for the population as a whole. Neither theory nor observations indicate that random pairing of binary components from the mass distribution, the simplest pairing function, is realistic. It is more likely that companion stars are formed in a disk around a star, or that a pre-binary core fragments into two binary components. The results of our analysis are important for (i) the interpretation of the observed mass ratio distribution and binary fraction for a sample of stars, (ii) a range of possible initial condition algorithms for star cluster simulations, and (iii) how to discriminate between the different star formation scenarios.

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Postdoctoral Research Fellowship in Theoretical and Computational Astrophysics

Job Description:

The astrophysics group at the Rochester Institute of Technology is seeking an outstanding postdoctoral researcher in theoretical astrophysics. We are particularly interested in candidates with computational experience, to make use of the superb facilities at RIT for gravitational dynamics simulations. These include a 32-node GRAPE cluster with a speed of 4 Tflops; three, GRAPE-6 computers; and a 110 node general-purpose cluster. Among the topics of current research interest at RIT are evolution of galactic nuclei, calculation of event rates for gravitational wave detectors, and interaction of supermassive black holes with their stellar and gaseous environments. Outstanding candidates in related fields will also be considered. The initial appointment will be for 2 years and may be renewable for a third year. To apply, please send a CV and statement of research interests and arrange for 2-3 letters of recommendation to be sent to David Merritt at merritt@astro.rit.edu before January 15 2009.

Further information can be found at the following URLs:

http://astrophysics.rit.edu/index.html
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POSTDOCTORAL POSITIONS IN THEORETICAL ASTROPHYSICS AT NORTHWESTERN UNIVERSITY

Job Description:

Several postdoctoral positions in theoretical astrophysics may be available in the Department of Physics and Astronomy at Northwestern University, starting in Fall 2009. The Theoretical Astrophysics Group at Northwestern currently includes Profs. Vicky Kalogera, Fred Rasio and Ron Taam, eight postdocs (Chris Deloye, John Fregeau, Loren Hoffman, Ilya Mandel, Soko Matsumura, Stefan Umbreit, Marc van de Sluys, and Bart Willems), as well as ten graduate students. We are interested in candidates with prior experience in any area of theoretical/computational astrophysics, but particularly the following: extrasolar planetary systems, compact objects, X-ray binaries, gravitational wave astrophysics and data analysis, and dense star cluster dynamics. Applications from women and minority candidates are especially encouraged.

Applicants should send their CV, list of publications, a brief statement of research interests (up to four pages), and arrange for a minimum of three recommendation letters to be received by December 1, 2008. Email submissions are preferred. Later applications will be considered until all positions are filled.

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Email Submission Address: w-finney@northwestern.edu
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The closing date for receipt of applications: 12/01/2008